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# Manufacturing Methods and Technology Program Automatic In-Process Microcircuit Evaluation

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report covers the work performed on the AIME equipment task during the period 1 April - 30 June 1978. It presents a technical and physical description of the Development Model equipment design and configuration. The work accomplished during the quarter and the task schedule are also presented. Plans for the next quarter have been developed and are outlined herein.

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The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

This project has been accomplished as part of the U.S. Army (Manufacturing Methods and Technology) Program, which has as its objective the timely establishment of manufacturing processes, techniques or equipment to insure the efficient production of current or future defense programs.

# TABLE OF CONTENTS

# TABLE OF CONTENTS (Cont.)

## LIST OF ILLUSTRATIONS

## LIST OF TABLES

# PURPOSE

The purpose of this program is to establish a Manufacturing Methods and Technology Program (MM&T) in accordance with Step 1, paragraph 1.2.2.1, of Electronics Command Industrial Preparedness Procurement Requirements (ECIPPR) No. 15, dated August 1976, for an Automatic In-Process Microcircuit Evaluator (AIME), which will establish techniques for the automatic inspection of thick-film conductor lines on substrates and the elimination of microscopes for visual pre-cap inspection of hybrid assemblies for use in Army electronic equipments. The MM&T program will include:

(1) System analysis to investigate hybrid image extraction techniques, illumination techniques, and RBV operating modes so that the basis for the AIME configuration can be established.

(2) Design of the AIME Demonstration Model, system software, and test program.

(3) Fabrication of the Demonstration Model Design. The system will contain all the necessary elements required to acquire test data on the inspection of substrate and hybrid assemblies to establish the basis for development of an AIME Equipment configuration and specifications for future procurement. The system elements will perform the following functions:

- Control of the AIME system
- Test program generation
- Stimulus and measurement, as required.

The AIME system will be demonstrated using a specially designed test pattern substrate and a typical hybrid assembly. Software will be developed to provide the control and evaluation required for the inspection of the test pattern substrate and hybrid.

In addition, an English Language Test Document (ELTD) will be generated for the inspection of the specially designed substrate and the hybrid assembly.

(4) A data package for the Demonstration Model will be provided including Test and Demonstration Report, Instruction Manual, Engineering Drawings, equipment specification, program listings, and ELTDs for the substrate and hybrid inspections.

This MM&T program is the result of work done on the Automated Image Device Evaluator (AIDE) Program, Contract DAAB05-74-C-2524. The purpose of the AIDE program was to provide the basis for automated inspection of second generation image intensifier tubes. This program will utilize AIDE hardware components in the design and fabrication of the AIME Demonstration Model.

# GLOSSARY

| | |
|---|---|
| AIDE | Automated Image Device Evaluator |
| AIME | Automatic In-Process Microcircuit Evaluator |
| ARTS | AIME Run-Time System |
| CLI | Command Line Interpreter |
| CPU | Central Processing Unit |
| DMA | Direct Memory Access |
| I/O | Input/Output |
| MAP | Memory Allocation and Protection |
| RBV | Return Beam Vidicon |
| RDOS | Real-Time Disc Operating System |
| TVL | TV Line |
| UUT | Unit Under Test |

# SECTION 1
## SYSTEM DESCRIPTION

This section is an update of the System Description contained in the Second Quarterly Report and includes system design changes incorporated in the AIME Demonstration Model during the third quarter.

## 1.1 TECHNICAL DESCRIPTION

### 1.1.1 General

#### Background

The Automated In-Process Microcircuit Evaluation (AIME) System will provide the basis for establishing test techniques for the automatic inspection of thick-film conductor-lines on substrates, and eliminate the need of microscopes for visual pre-cap inspection of hybrid assemblies.

There are many points, during the manufacture of hybrid microcircuits, at which some degree of visual inspection is made. However, there are specific major points at which 100 percent visual inspection is made. These inspection points are:

(1) After thick-film processing of the substrate is complete (before the start of assembly).

(2) Immediately before sealing the assembled hybrid package (pre-cap visual).

There are additional significant points, during the thick-film processing of ceramic substrates, where 100 percent continuous inspection would be very desirable, but the costs of manual inspection are prohibitively high and the inspection process itself impedes the achievement of desired throughput rates for printing, drying, and firing. A viable system of automatic in-process inspection among the operations involved in adding a thick-film layer to the substrate lot, would greatly improve the yields and assure a more dependable end product.

Figure 1-1 shows a simplified process flow drawing for the manufacture of thick-film hybrids from the point of cleaning the alumina substrates to the point after assembly where the hybrid circuit is hermetically sealed. This process flow drawing is arranged to highlight those visual inspection points located in three major areas of the process sequence.

At process point 1A, immediately after printing, a rejected substrate can readily be washed off with a suitable solvent. If the flaw was caused by a problem in the printing process (such as a clogged screen), corrective measures could be taken before too many of the bad prints were made.

At the drying or baking process point, 1B, certain trapped particles, such as lint and dust, could be detected. If flaws are detected at this point, the dried material can be removed from the substrate (more vigorous cleaning is required). Again, as in the case of the substrates with set ink, the plates are recovered and the value added to the substrates in earlier steps is not lost.

Inspection at point 1C occurs after each successive printed layer is fired. The value of picking up faults at this point is to avoid any further labor on a defective substrate, take corrective action as appropriate on any possible out of control process and perform any acceptable, cost-effective rework to the rejected substrates.

Figure 1-1. Manufacturing Process Flow with Inspection Points

Inspection point 2 on the process flow drawing, identifies the last action to be performed on a substrate before forwarding it to the assembly operations where chip parts are attached and where semiconductors are connected by wiring bonds to the substrate metalization. As previously mentioned, this is a 100 percent inspection point. Automatic inspection on an in-process basis should make this pre-assembly inspection far less important. An interactive inspection system would provide the operator with the ability to identify marginal situations. After electronically zooming in on the area of interest the display on a large screen video monitor would allow the operator to inspect the suspicious area in detail.

At process inspection point 3 (pre-cap visual inspection) a 100 percent inspection is also routinely made of the completed hybrid assembly. At this inspection point the inspection system could be preprogrammed to a disciplined sequence of displayed substrate areas to make sure that the visual inspection is thorough and looks closely at any specific area that is particularly vulnerable to flaws in the manufacture.

## System Components

Figure 1-2 is a simplified block diagram of the AIME Demonstration Model. The basic components of the system are:

(1) Control/Display Station

- Computer and Peripherals
- Video Processor and I/O Control
- RBV Electronics, Power Supply
- Sync Generator
- Time-Base Corrector
- Video-Disc Recorder/Reproducer
- Video Monitor
- Illumination Power Supplies

1-4

COMPUTER DG S/130 ECLIPSE

DISC 10MB DG 6045

DISPLAY/KEYBOARD DG 6053A

CHARACTER PRINTER DG 6041A

LEGEND

C = COMPUTER CONTROL
M = MANUAL CONTROL
△ = BUILD
▲ = GFE
◢ = PURCHASED

DIGITAL DATA

CONTROL

VIDEO PROCESSOR

I/O CONTROL

COLOR VIDEO MONITOR

SYNC GENERATOR

POWER DISTRIBUTION

115V, 3∅

CONTROL/DISPLAY STATION

C

DISPLAY VIDEO

RBV VIDEO

CORRECTED VIDEO

RBV ELECTRONICS & RBV POWER SUPPLY

RECORD VIDEO

VIDEO DISC RECORDER

TIME-BASE CORRECTOR

ILLUMINATION POWER SUPPLY

M

C

M

C

C

M

NON-COMPOSITE VIDEO

ZOOM & X-Y POSITION

LAMP

RBV HEAD

LENS

A/C

LAMP

UUT

UUT HOLDING FIXTURE

OPTICAL TABLE
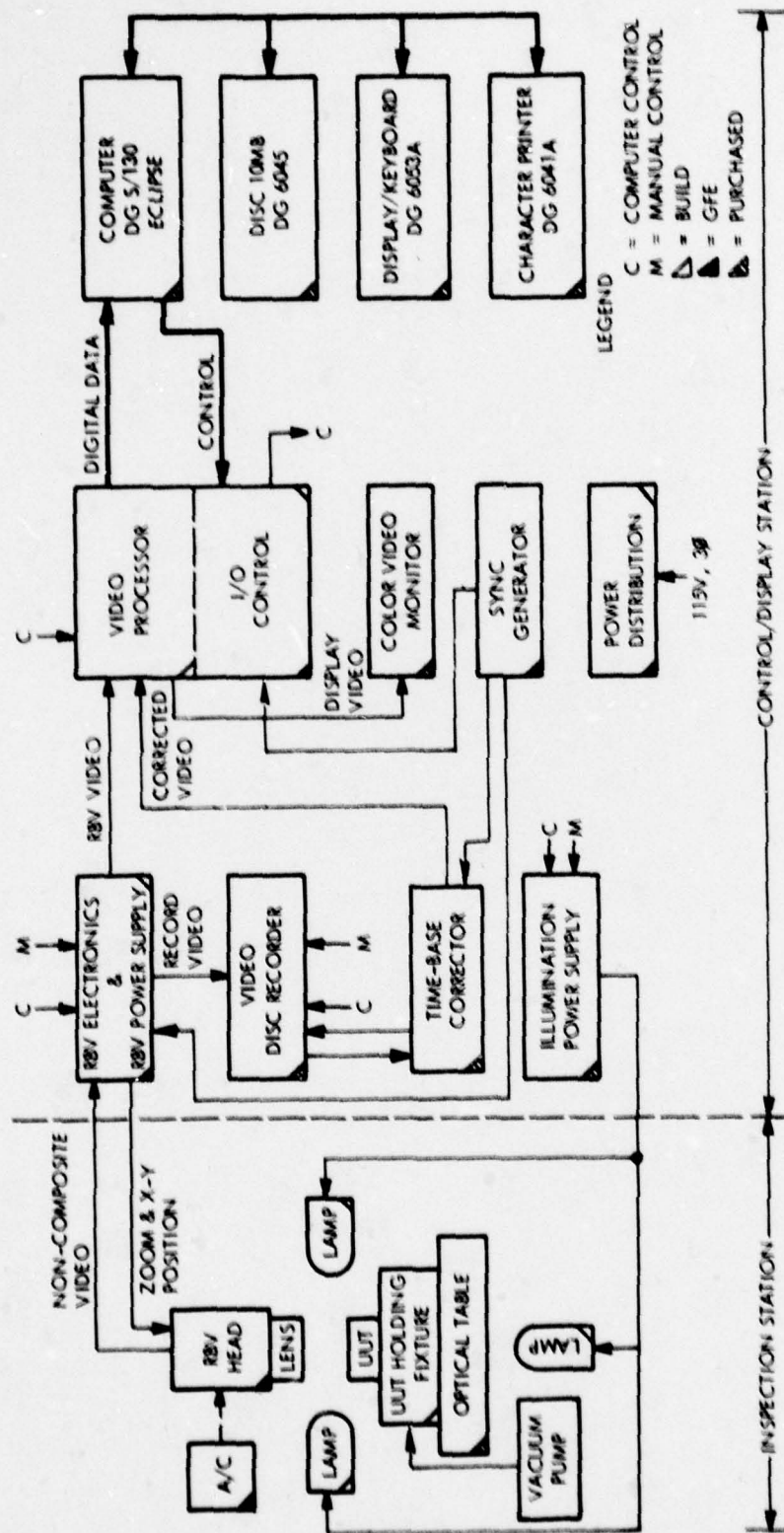
LAMP

VACUUM PUMP

INSPECTION STATION

Figure 1-2. AIME Demonstration Model - Block Diagram

1-5

(2) Inspection Station

- RBV Camera Head with Lens
- Illuminators (Lamps)
- UUT Holding Fixture
- Optical Table with the Structure/Shroud Assembly
- Air Conditioner Unit

The legend, in Figure 1-2, identifies those items which are under computer control and/or manual control. Further, the legend also shows which of the components are to be built (new designs), purchased (modifications as necessary), and GFE (modified as necessary). All GFE items are removed from the AIDE system (Contract DAAB05-74-C-2524).

## Operation

The following is a general description of a typical substrate inspection process performed by the AIME system. The UUT is placed in the holding fixture and subsequently illuminated, projecting the UUT image on the RBV face. The AIME Control selects and positions the RBV scan, via the RBV electronics, to the desired UUT image area to be viewed. The RBV output is a video signal which is directed to the RBV electronics and then to the video processor. A pre-recorded image of the same UUT area is obtained from the video disc-recorder and directed to the video processor.

The video processor performs two functions. First, the difference between the RBV video signal and the video disc-recorder signal output is taken, digitized and fed into the core memory of the AIME system computer. Second, the processor takes the same difference video signal and combines it with the RBV video signal which is then displayed on the color video monitor.

The combination of the difference and RBV video signals is such that the RBV output appears as a black and white image on the monitor. The difference video is directed to the red and green gun-driver circuits. Thus, if the RBV image is wider than the recorded image the green color-gun output will be increased resulting in a highlighting of the greater than normal UUT area. A similar result is obtained if the UUT image is narrower than the recorded image, except now the red color-gun output is increased.

When the inspection is complete the AIME control repositions the RBV beam scan to the next UUT area to be inspected, and repeats the above process until the UUT inspection is completed.

The hybrid-assembly inspection is similar to that described above for the substrate inspection, except that the video disc-recorder is not used and the color highlighting of an out-of-tolerance area is not generated.

## 1.1.2 Control/Display Station

The major elements of the Control/Display Station are shown in Figure 1-2. One of the two major functions performed by this station is control of the AIME operating modes. This control is maintained by the computer and associated peripherals. Table 1-1 identifies the selected models and key features of these items.

The remaining elements of the Control/Display station are associated with the RBV and Video Processor. Among these items are certain units which are purchased from selected vendors. These items include the video disc-recorder, sync-generator, time-base corrector, color video monitor, and illumination power supplies. These items are also in Table 1-1.

The two methods of controlling the AIME system are with the computer and associated interface (CPU control), and with controls located on the front panels of the RBV electronics chassis, the video processor chassis, and the video-disc recorder (Local Control).

Table 1-1. Control/Display Station Elements

| Device | Model | Features |
|--------|-------|----------|
| Computer | ECLIPSE Data General (DG) | 64K words, memory allocation and protection (MAP), 700 nsec memory cycle |
| Disc Subsystem | 6045 (DG) | 10 megabyte storage, removeable disc-pack unit |
| Display/Keyboard | 6053A (DG) | Detachable keyboard, 96 ASCII character set, 5 x 7 dot matrix, 1920 character storage, user-defined keys |
| Printer | Dasher 6041A (DG) | 60 cps, 40 character buffer memory |
| Video Disc Recorder | VDR-1RA ARVIN-ECHO | 400 frame storage, variable frame step-rate, remote control |
| Time Base Corrector | DPS-1 Digital Video Systems | Will correct greater than 2 $\mu$sec of jitter to better than 10 nsec |
| Color Video Monitor | 5411RS19 Conrac | High resolution color monitor |
| Illumination Power Supplies | 6329 Oriel | Stabilized power supply for Quartz Halogen Illuminators |
| Sync Generator | Tektronix 1410 | Provides horizontal and vertical drives as well as Composite Sync and Blanking signals |

When the AIME system is being operated by the front panel controls, the computer does not influence the system operation.

## 1.1.2.1 CPU Control Mode

Under CPU Control, all elements of the AIME System are operated by computer generated commands with operator interventions as required. The primary computer/operator interface is the display/keyboard. The color video monitor is a secondary interface element.

Three basic operating modes are possible under CPU Control. These are:

- Manual Inspection

- Semi-Automatic Inspection

- Automatic Inspection (Demonstration System).

The Manual Inspection operating mode allows the operator to select the desired RBV scan position, zoom-ratio, illumination, as well as the color video monitor display. The operator controls these parameters by 1) depressing the appropriate key on the keyboard, 2) observing on the computer interface display that his selection was accepted and executed by the computer, 3) verifying on the video color monitor that he has the correct view. The operator may then modify the present monitor image or continue with the Manual Inspection.

In addition to the Manual Inspection just described, the operator may also create an inspection program by entering the Program Generation option of the Manual Inspection Mode. With this option, the operator may select the desired monitor view and then depress a keyboard button which will then generate the AIME computer commands required to duplicate the view being observed. Thus, an Inspection Program may be generated by the operator, without any prior knowledge of the AIME System language.

Figure 1-10 shows the keyboard layout with the associated AIME System commands.

The Semi-Automatic Inspection mode is utilized after an inspection program has been generated. In this mode the computer sequences through the predetermined inspection steps, presenting on the monitor a view for the operator to inspect the substrate or hybrid. The operator evaluates each substrate and presses the appropriate button on the keyboard. The computer does not evaluate the video signal except as the operator indicates by his keyboard entered response.

The Automatic Inspection Mode for the AIME Demonstration System will, under computer control, set up the RBV camera operating mode, select the correct stored image on the video disc recorder, input and evaluate the video difference data, and continue the inspection process until a fault is found or the substrate inspection has been completed.

Essential for implementing the CPU control mode, is an interface board within the S/130 computer. This board, referred to as the 4040 board, contains circuitry which performs two functions: 1) Transfer of digital words to the AIME system which are used to control the AIME system elements. 2) High-Speed transfer of digital words, which represent the video image, into the computer core memory. This board communicates with the AIME system via a bi-directional data-bus routed to the IO circuitry, located in the IO processor chassis (paragraph 1.1.2.4).

Careful partitioning of the high-speed or DMA circuitry, allows for the use of a minimum of data and control lines between the computer and the IO circuits. A total of twenty-seven differential lines make up the AIME computer interface. A discussion of the computer interface is given in paragraph 1.1.2.4.

### 1.1.2.2 Local Control Mode

The LOCAL control mode is intended as a setup, diagnostic, or evaluation aid. It is not intended for use by an unskilled operator.

This control mode allows the AIME system to be operated in a manner similar to that of the CPU mode. The distinguishing difference between the two control modes is that the computer control is completely removed from the system. Instead, control of the AIME system components is accomplished by controls on the front panels of each of the following components: the RBV electronics chassis, the IO processor chassis, and the video disc recorder.

The details of these front panel controls are given in the descriptions which follow.

### 1.1.2.3 Power Distribution

AIME power distribution is centralized in one chassis. This chassis contains all the required circuit breakers for controlling the main power to the RBV electronics, the illumination power supplies, computer and the associated peripherals, video devices, the I/O processor chassis and the air conditioner/vacuum pump.

### 1.1.2.4 IO Processor Chassis

The IO processor chassis contains three main elements: the IO circuitry, the video processor digital, and the video processor analog circuits. This chassis has four low-voltage power supplies which provide +5, -5, +24, and $\pm$ 15 volts DC. The CPU control structure is illustrated in Figure 1-3.
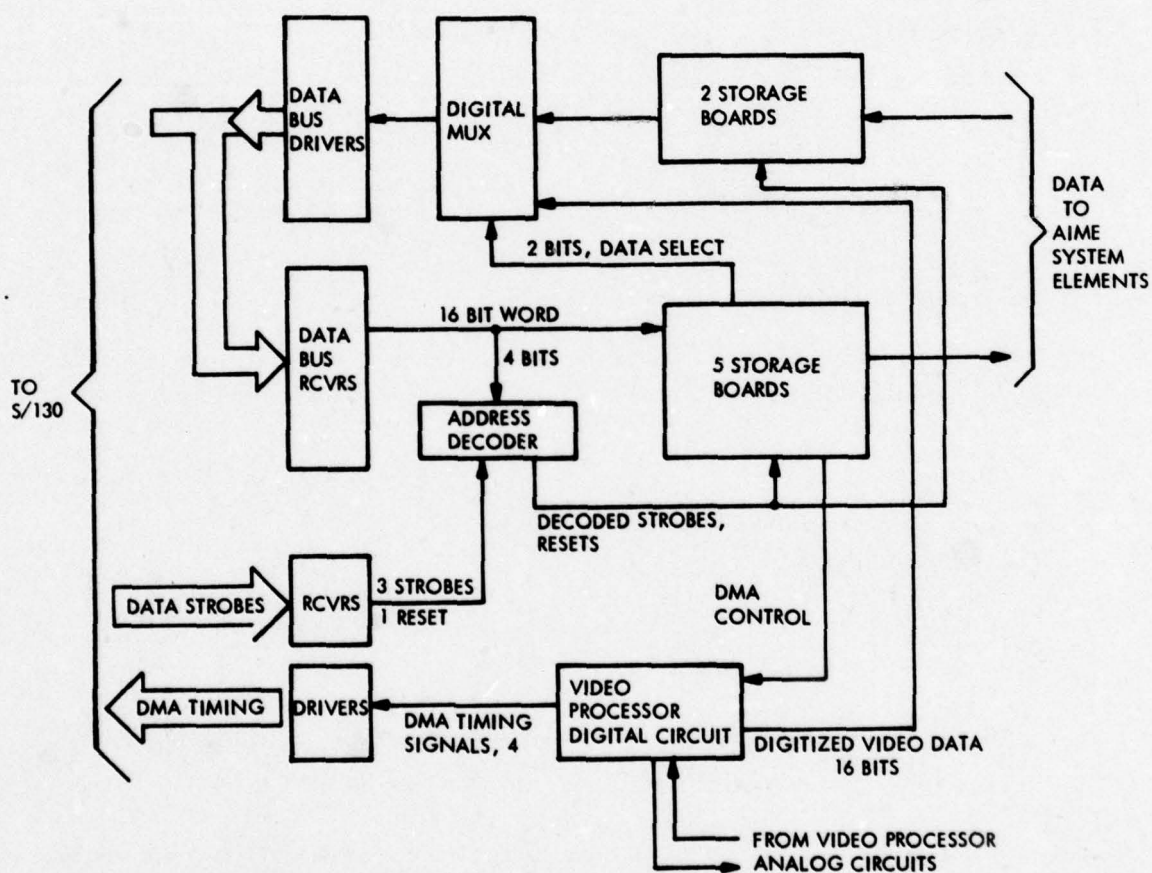
Figure 1-3. AIME CPU Control Structure

## IO Circuits

These circuits provide the main link between the computer and the AIME system. Data-bus receivers and drivers provide the actual data link as well as sending system timing signals to the computer. An address decoder and seven storage cards provide the means by which the CPU Mode of control is implemented.

Data from the computer is presented on the data-bus and detected by the receivers as shown in Figure 1-3. A strobe pulse is used to capture the data. Sending data to the IO circuits is a two-step process:

1) The data-bus direction is set to "output" while placing on the data-bus a 16-bit word. Four of the bits are used to select the desired storage board. A strobe pulse latches the 4-bits in the address decoder.

2) A second 16-bit word, representing the computer command word, is then sent along with another strobe pulse. The strobe pulse is routed through the address decoder to the "addressed" storage board. The data-bus direction is returned to "input". (For speed considerations the normal state of the data-bus is the "input" state).

The storage cards are wired to the appropriate AIME system element. Inputting data from the AIME system is a three-step process.

1&2) Using the "output" sequence described above, the AIME element to be read is selected by routing the data through a digital multiplexer to the data-bus

1-13

**9.53 MHz** ───────── **÷1.5** ◄─── **14.3 MHz**

**POWER ON RESET** ──● **FIRST FIELD**

**FIRST FIELD**

**VERTICAL SYNC**

**VERTICAL SYNC GENERATOR** ◄─── **VERTICAL DRIVE**

**HORIZONTAL DRIVE**

**SERIAL-TO-PARALLEL CONVERTER** ◄─── **COMPOSITE BLANKING**

**PARALLEL LOAD**

**PARALLEL VIDEO DATA**

**SERIAL VIDEO DATA**

**HORIZONTAL SYNC**

**SIGNALS TO COMPUTER**
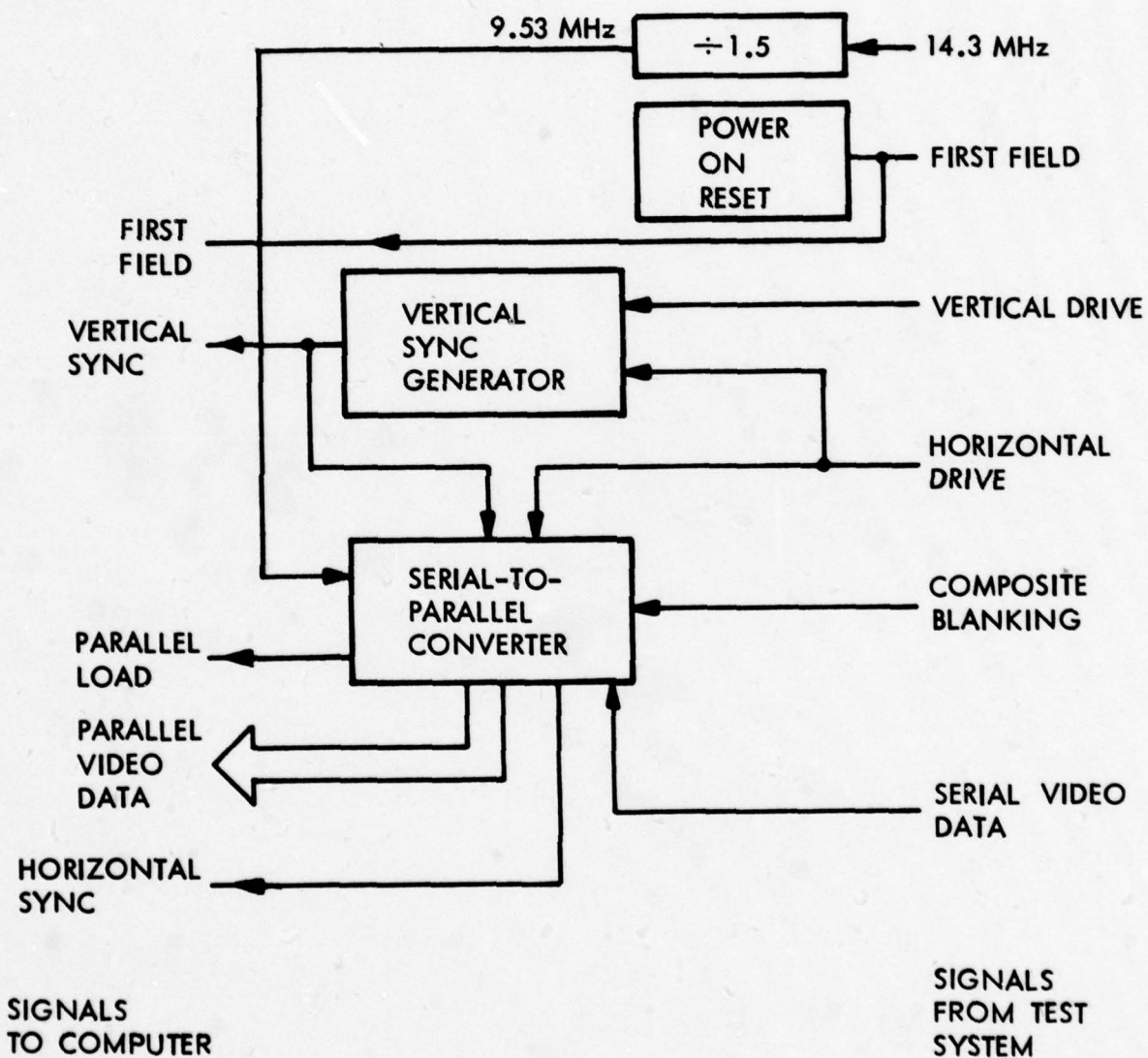
**SIGNALS FROM TEST SYSTEM**

Figure 1-4. Video Processor Digital Circuits Block Diagram

1-14

drivers.  A two bit code is used to select the data.

3)  With the data-bus in the "input" state the routed data is strobed into the computer.

Video Processor Digital Circuits

The video processor digital circuits generate all the functions to provide the high-speed data transfers from the AIME system into the Computer Memory.  In addition, these circuits generate the system timing signals required by the computer.  Figure 1-4 shows the video processor digital circuits in the CPU control structure.

The video processor digital circuits perform two main functions:

1)  Convert the serial digitized video data into parallel 16 bit digital words.

2)  Generate the timing signals required to perform the DMA data transfers.

As depicted in Figure 1-4, these circuits require signals from the system sync generator and the TBC.  The sync generator provides the first-field, vertical drive, horizontal drive, and composite blanking signals while the TBC is the source of a 14.3 MHz clock signal.  The serial video data is obtained from the video processor analog circuits.

AIME Video Processor Analog Circuits

The video processor analog circuits provide the following functions:

(1)  Display switching

(2)  Differencing of live and playback video

1-15

(3) Display color enhancement

The video processor, fabricated in a single copper clad board, is housed within a separate package.

Display switching is performed by relays on the video processor board. These relays function either under CPU control or under the control of a rotary display select switch on the IO/Processor front panel when the system is in the Local Operate or Local Setup Modes, and route the video signals to provide the selected display. The selectable options are live video $(V_A)$, playback video $(V_B)$, $V_A$ with the difference between $V_A$ and $V_B$ superimposed in color and a special video processor setup display in which $V_A$ is differenced with itself and any residue is superimposed on $V_A$ in color.

The analog differencing circuits subtract the live video $(V_A)$ from the playback video $(V_B)$. Nominal 1.0 volt p-p composite video/sync is fed to the processor via the $V_A$ and $V_B$ connectors on the rear of the chassis. $V_B$ is fed directly to an input attenuator; $V_A$ is fed to a filter network and then to an attenuator. The purpose of the filter network is to adjust the transfer characteristics of the line video channel to compensate for the disk recorder and TBC characteristics introduced in the playback channel. The final form of this filter network cannot be determined until system integration.

The two input attenuators enable setting identical video peak white to video black (not sync) levels in both channels. Once these levels have been equalized, it is possible that different sync levels may exist in two channels. To correct this, each channel passes through a threshold network where the sync tips are self-clamped to an adjustable level

by diodes. These levels can be adjusted independently to cause the sync in each channel to be clipped by an equal amount below the video black level. This same network also established the DC input level for the following video differential amplifier. At the output of this network, the two video signals are identical (except for valid differences) between the master and UUT images, the sync tips have been clipped, and the signals are clamped to the same DC level.

The video is differenced in a dual output video amplifier. The two raw difference outputs corresponding to $V_A - V_B$ and $V_B - V_A$ are then fed to comparators, the differences are compared to adjustable thresholds and bilevel video outputs are generated whenever the raw video difference exceeds the threshold. Both bilevel outputs are high for differences greater than the threshold levels.

These two bilevel outputs are routed out of the video processor analog circuits to the digital circuits and are also routed within the video processor to the color enhancement network.

The color enhancement circuits present the difference video on the video monitor. The two bilevel outputs are routed through AND gates (which are enabled only when valid differences can exist) to the video driver network. This network consists of three amplifiers for driving the red, blue and green guns of the color video monitor. The live video input ($V_A$) is passed directly to the three drivers; this allows generating a black and white image of the UUT. The two bilevel difference outputs are summed into the live video signal ahead of the red and green drivers. Whenever these two levels are high (differences greater than thresholds, the black and white image will be superimposed with red or green color

splashes showing the location of differences. Green will correspond to $V_A - V_B$ (UUT less dense than the master, back lighted mode); red will correspond to $V_B - V_A$ (UUT denser than the master, backlighted mode).

### 1.1.2.5 RBV Camera System

The RBV camera system, diagramed in Figure 1-5, consists of the following:

- The RBV electronics chassis.

- The RBV power supply chassis.

- Sync generator.

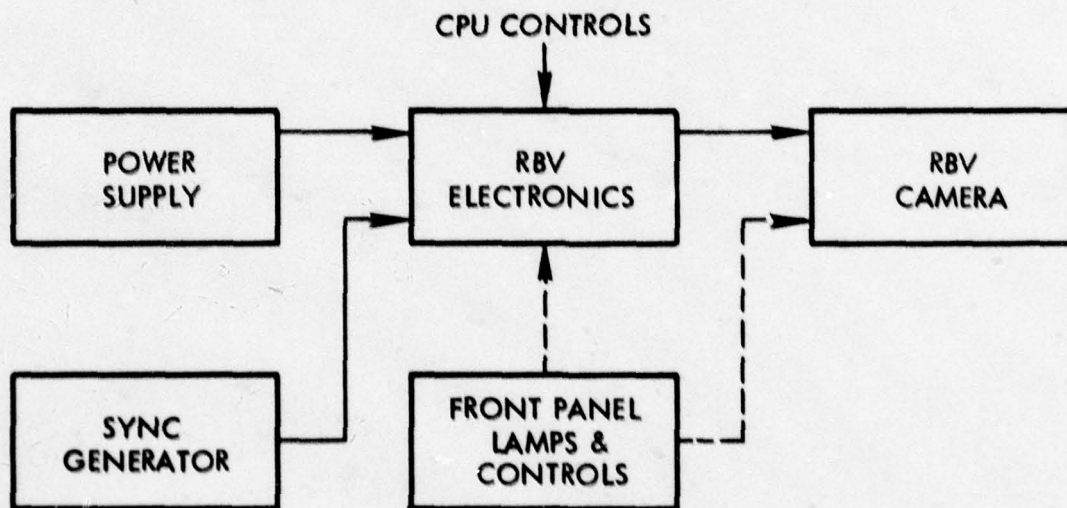- Lamps and controls.

- RBV camera.



Figure 1-5   RBV Camera System

## Camera Electronics

The camera electronics is located in the RBV electronics chassis. Its purose is to provide sweep signals and video signal conditioning for the RBV camera. This assembly contains twelve plug-in circuit boards (A1 through A12), two power supplies, front panel controls/ indicators, and a horizontal deflection driver.

- **Horizontal Deflection Waveform Generator, A1**

  This board contains a ramp generator used to provide linearity correction to the horizontal yoke driver. The ramp generator operates at the horizontal scan rate.

- **Protection Circuits, A2**

  These circuits detect the loss of horizontal and vertical deflection. Loss of either signal shuts down the high-voltage power supplies and lights the fault light on the RBV control panel.'

- **Vertical Deflection, A3**

  This board contains an oscillator, buffer, and yoke driver circuits. The buffer also sums the vertical steering voltage which provides vertical position control.

- **Sync Buffers, A4**

  Optical isolators are used to buffer and level shift the horizontal drive, vertical drive, and composite blanking signals from the sync generator.

- **Target/Focus, A5**

  This board generates a stable voltage reference and the focus coil and target drive signals.

- Beam/Alignment, A6

  The horizontal and vertical alignment coil drive signals are generated on this board. The bias voltage for the RBV tube grid, G1, is also obtained from this card. There is also a circuit which produces a delayed clamp pulse which is supplied to A12.

- Electrode Regulator, A7

  This board provides regulated bias voltages for the RBV tube grids, G2, G3, G4, G5, and G6.

- Beam and G4 Focus Control, A8

  This assembly controls the beam and G4-focus voltages in accordance with the zoom ratio. A two bit binary word is used to specify the zoom ratio (1:1, 1.67:1, 3.60:1, and 10:1). The binary word is decoded to select a preset potentiometer for control of the beam and G4-focus voltages.

- Vertical and Horizontal Digital-to-Analog Converters, A9, A10

  A9 and A10 are identical circuits used to control the vertical and horizontal position of the RBV beam. The beam position can be selected by the computer under CPU control or by the front panel switches under local control. The output of these boards (A9 and A10) provide the beam steering voltages to assemblies A1 and A3 respectively.

- Target, Horizontal Size, and Dynode Gain Control, A11

  This assembly controls the target, horizontal size, and dynode gain signals based on the selected zoom ratio. Control of these signals is similar to that for the A8 board, i.e., a preset potentiometer is selected. In addition, drivers are provided for the front panel lamps which indicate the selected zoom ratio.

- **Video Driver/AGC, A12**

  A12 buffers and amplifies the video from the RBV camera. The buffered outputs drive the time-base-corrector, video processor, and the video monitor. In addition, this assembles the black burst and horizontal blanking levels to the video signal. On AGC circuit is provided for the video preamplifier located in the RBV camera.

- **Horizontal Deflection Driver, A14**

  The horizontal deflection driver is a resonant flyback circuit operating at 15750 Hz. This board also provides linear correction and a summing point for the horizontal steering signals. Relays on the board provide the proper operation in accordance with each zoom ratio.

- **1500 V Supply, A18**

  A 900 V to 1200 V power supply is provided to drive the dynode as required by the corresponding zoom ratio.

### RBV Power Supply

This assembly provides several DC voltages to the RBV electronics and camera assemblies. These voltages are $\pm6$, $-6.3$, $\pm15$, $\pm25$, $-400$, $+700$, $+2500$. The assembly operates from 115 V, 60 Hz.

### RBV Camera

The RBV camera consists of an RBV tube, the camera head electronics, and the focus and deflection coil assemblies. The camera receives sweep, and control grid voltages from the RBV electronics and returns a video signal which represents the image on the RBV tube face.

Sync Generator

The sync generator provides the sweep signals to the RBV electronics. These signals are vertical and horizontal drive, black burst, and composite blanking. This is a separate rack-mounted unit.

1.1.2.6 Illumination

The illumination system consists of an illumination controller, three illumination power-supplies, and three illuminator housings.

The illumination controller provides an intensity control signal to the illumination power-supplies. This provides for variation of the illumination intensity based on the selected zoom ratio. Zoom ratio information comes from the RBV electronics. Time delay relays are included to provide a lower than normal "cold-start" voltage when an illuminator is turned on.

The illumination power-supplies provide the voltages for the quartz-halogen lamps in the illuminator housings. There is one power-supply for each lamp. Remote sensing was added to each power-supply to compensate for voltage drops in the cables which connect the lamps with the power supplies. The remote sensing also helps to maintain a consistent voltage across the lamp for each preset illumination level.

The main power (115 V, 60 Hz) for the power-supplies is derived from the power distribution panel. There are two switches in the power distribution panel to manually operate the illuminators.

### 1.1.2.7 Video Devices

Four video devices complete the Control Display Station: the video disc recorder, time-base corrector, color video monitor, and sync generator.

The video disc recorder is used to store the image which is compared to the RBV video. The image stored on the video disc is $V_B$ discussed in paragraph 1.1.2.4. This unit can store up to 400 images. A remote control connector enables the unit to be controlled by the computer. A minimum of interface circuitry, located in the I/O Processor chassis, completes the interface.

The time-base corrector (TBC) unit aligns the playback video, $V_B$, with the RBV camera video, $V_A$, to within 10 nsec. The reference signal is obtained from the sync generator unit described below. The TBC front panel provides a fine-timing of the alignment of $V_B$ with respect to $V_A$.

The TBC also supplies a 14.3 MHz clock signal to the video processor digital circuits (paragraph 1.1.2.4). A color monitor unit is used to provide the operator with a display of the $V_A$, $V_B$, or $(V_A - V_B) + V_A$ video signals. The monitor uses the system sync generated by the sync generator. A test signal is routed through an auxiliary video channel for alignment of the monitor. Video drive signals are routed from the AIME video processor (see paragraph 1.1.2.4) to each of the color-gun drive inputs.

A sync generator is provided as the AIME system time-base. The sync generator provides a variety of timing and drive signals to various elements of the AIME system. Four signals

are routed to the RBV Camera System (paragraph 1.1.2.5): vertical drive, horizontal drive, composite blanking, and black burst. The video processor digital circuits (paragraph 1.1.2.4) utilize the first-field, vertical drive, horizontal drive, and composite blanking signals. A color bar test pattern signal is routed through the TBC and terminated in the color monitor. This signal is the system reference for the TBC and a test signal for the color monitor.

### 1.1.3 Inspection Station

The AIME project proposal contained a preliminary concept for the Inspection Station. This concept envisioned a structure consisting of aluminum framing material would be used to support the RBV camera assembly. The aluminum frame material is readily available in standard sizes and thus provides an economic as well as rigid support for the RBV camera. The shroud consists of aluminum plates attached to the structure assembly. The shroud material will contribute to the overall rigidity. The Inspection Station is diagrammed in Figure 1-6.

Further analysis indicated, however, that the structure/shroud would have insufficient rigidity to maintain the 0.0005 inch orthogonality between the camera and holding fixture. A more rigid camera support has been designed using bolted aluminum plates. The camera support, which is similar in appearance to a microscope mount, will be fastened directly to the optical table surface. In addition to providing more rigidity for the camera, the camera support provides a convenient mounting structure for both illuminators and mirrors.

A third illuminator, located on the optical table, has been provided to produce a back lighting mode. Light from this illuminator will be folded $90^o$ by locating a mirror beneath the holding fixture (see Figure 1-7). Since scattered light from the illuminator or mirror incident on the front surface would decrease contrast, a bellows will be used to completely enclose the light path between the illuminator and holding fixture.

Incident illumination remains essentially unchanged from that in the AIME proposal. That is, the two illuminators are located $180^o$ apart and the slightly defocused filament is imaged on the hybrid. Illumination angle established by the Illumination Analysis (reported in the first quarterly report, Appendix 2) for both illuminators remains approximately $20^o$. In order to uniformly illuminate the 2" x 2" hybrid with the defocused filament image, the illuminators must be located 20 inches from holding fixture. Since the illuminators are

RBV

ILLUMINATOR

MIRROR

OPTICAL TABLE

HOLDING
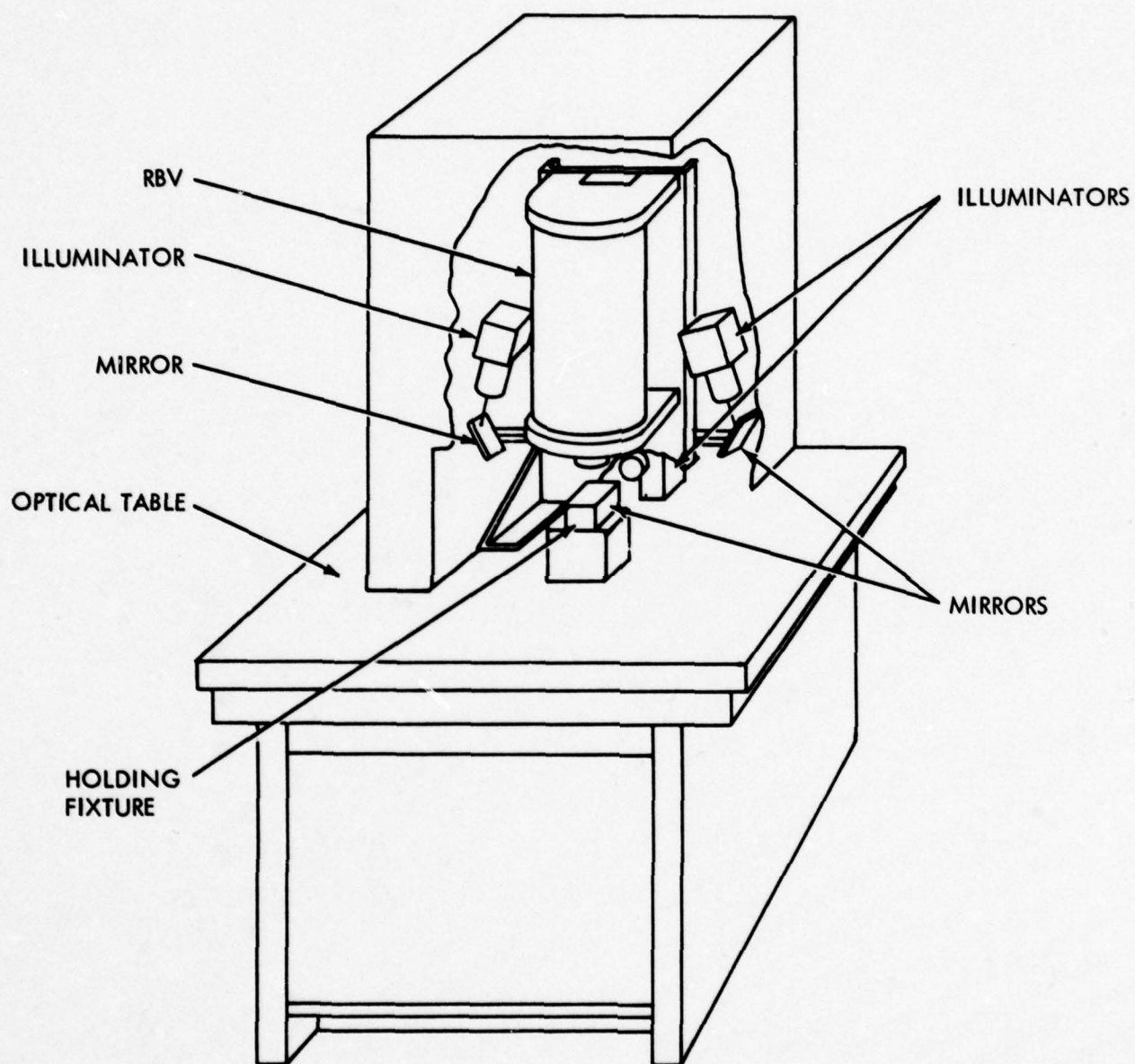FIXTURE

ILLUMINATORS

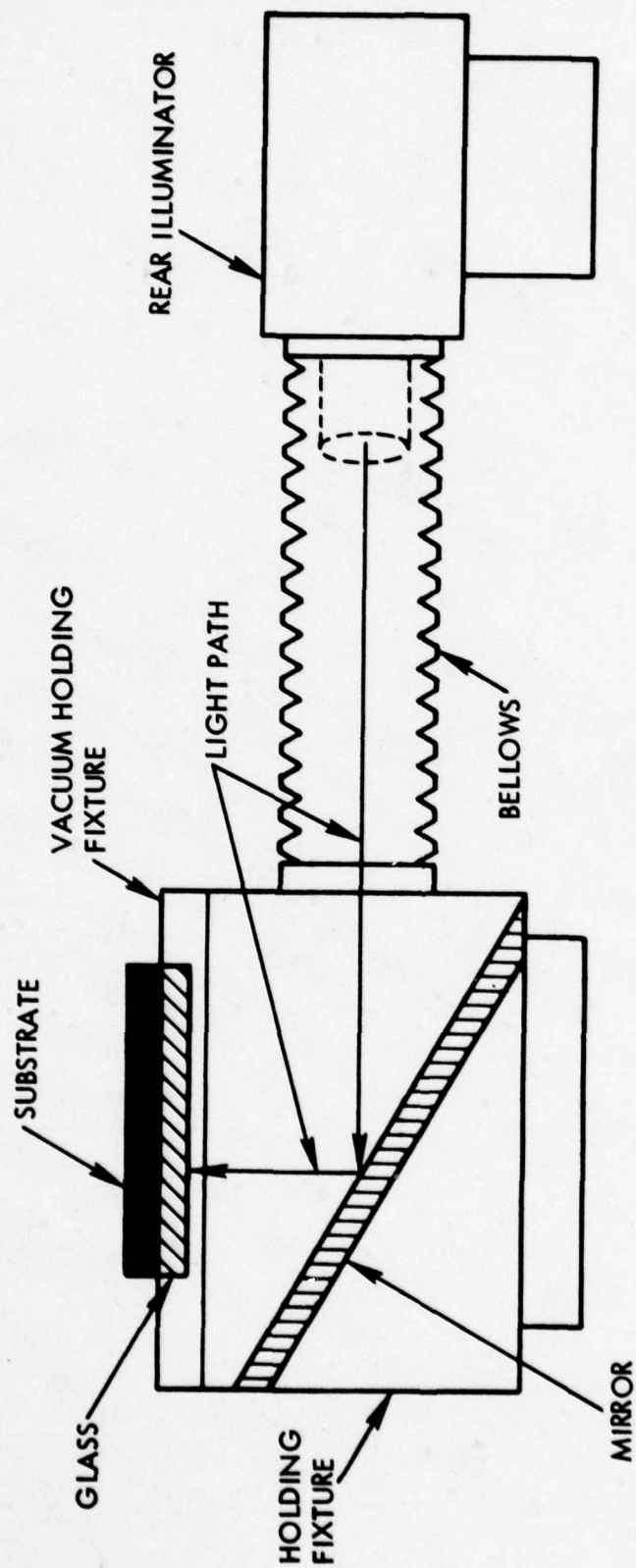MIRRORS

Figure 1-6. Inspection Station

Figure 1-7. Rear Illumination

located 180° apart, the inspection station became four feet wide. To reduce the overall station width, both illuminators are now mounted parallel to the RBV camera and adjustable mirrors are used to fold their beams (see Figure 1-9). The outside dimensions for the shroud are now approximately 26" wide x 28" deep x 36" high.

It was determined that vibrations generated by the illuminator cooling motors would cause RBV camera imaging difficulties. Therefore, the motors will be disconnected and external cooling air from the air conditioner unit will be ducted to each of the three illuminators. Air from the illuminators will be exhausted directly into the shroud, thereby creating a slight positive pressure inside the shroud. This positive pressure will preclude dust inside the shroud.

A mirror housing is located just below to the vacuum holding fixture to facilitate back lighting. Since the back lighting mirror is located directly under the holding fixture, no change will be required for the x, y, z and $\theta$ hybrid holding fixture positioning units.

### 1.1.4  AIME Software

The AIME System Software will consist of Data General Real-Time-Disc-Operating System (RDOS), the Command-Line-Interpreter (CLI), the AIME-Run-Time System, and various utility programs.

### Real-Time-Disc-Operating System (RDOS) and CLI

RDOS is a comprehensive and flexible operating system normally used with disc-based NOVA systems. RDOS provides a comprehensive file system that gives the user a simple command language to edit, compile, execute, debug, assemble, save, and delete files. File protection is provided by a number of system-defined file attributes. All peripheral devices are names and treated as files, providing device independence by device name. RDOS provides an I/O facility with buffered and spooled operations. The operating system allocates unused core storage for dynamic system buffers and overlays.
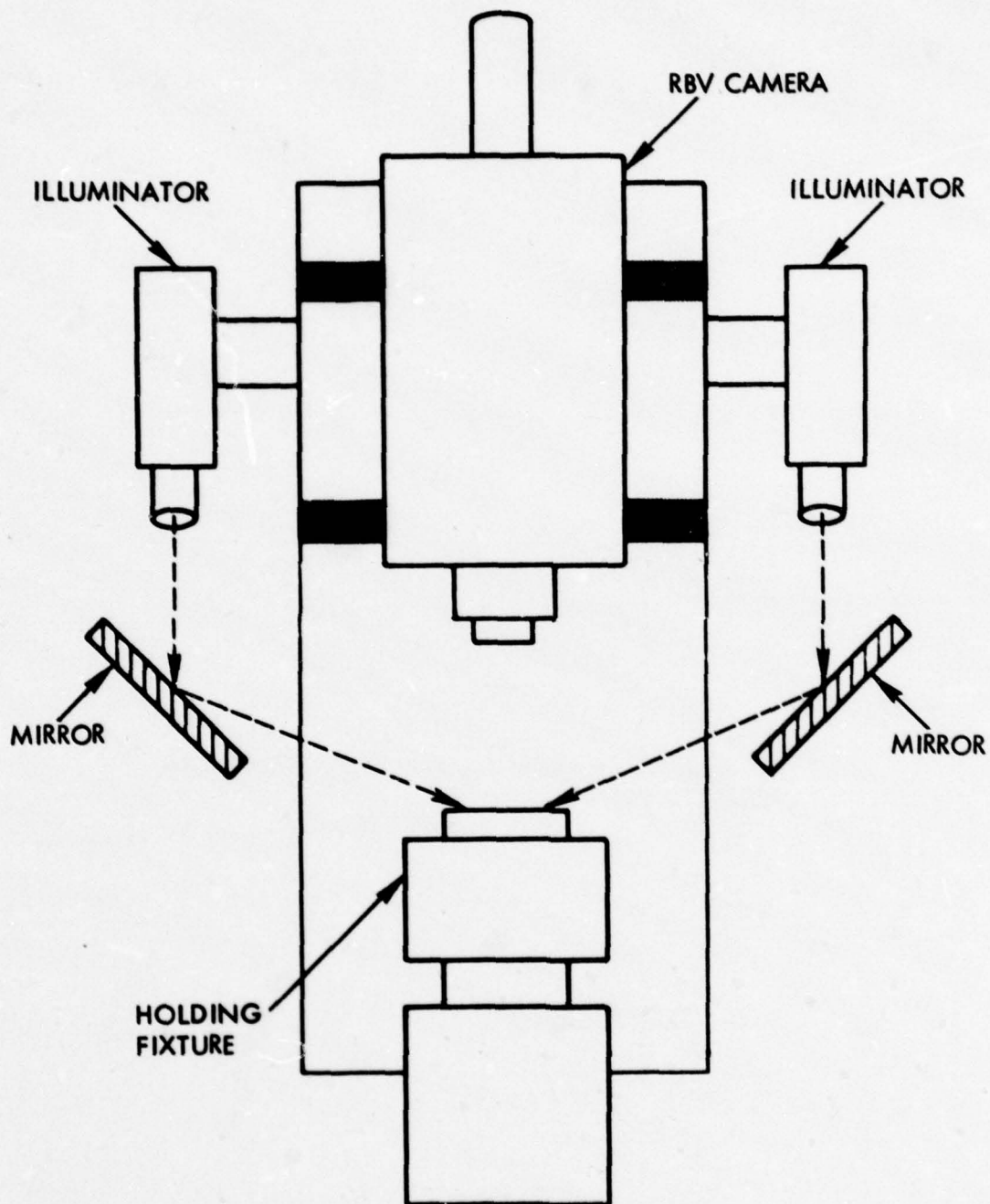
Figure 1-8. Front Illumination

The Command Line Interpreter (CLI) is a dynamic interface to RDOS via the console and translates the input as commands to the operating system. The system restores the CLI to core whenever the system is idle - after initialization, after a disc bootstrap, after the execution of a program, etc. The CLI indicates that it is in control by inputting a ready message "R" followed by a carriage return.

Run-Time System

General

The AIME Run-Time System (ARTS) will perform the functions of program generation, and test execution. It will be written in high level language (ALGOL) utilizing structured programming techniques to obtain modularization for ease of maintenance and understanding. Assembly language modules shall be minimized and used only where necessary for speed or special purpose programming such as required in image processing. Certain existing software modules from the AIDE System have been used with minor modifications: AIMERTS INIT, GETLINE, LIGHT, READINPUT, READMEAS, RTSEXT, RTSTERM, and WAITFOR. The ARTS will operate under RDOS Rev 6.

The highest level software module will function an an interpreter which can be utilized in an on-line mode (manual mode), or execute a previously generated test sequence (auto or semi-auto modes).

Program generation will be accomplished either on-line or off-line. On-line program generation will allow the user to try various setups for X-Y position, zoom, illumination, etc. When a specific test setup is decided upon, the system software will remember, on operator command, the exact setup and will place the test setup in sequence with respect to other tests. Off-line programming will be accomplished by writing a legal sequence of interpreter commands and data. Upon execution of a program, any illegal commands or missing data will result in error messages being displayed to the user.

The result of either off-line or on-line program generation will be a source file listing, comprised of interpreter commands and data. This test program sequence will be readily modifiable, through the use of a text edit program similar to the one used on the EQUATE AN/USM-410 system.

Actual testing will be initiated by typing in the command 'TEST' on the CLI. If TEST/A 'NAME' is entered, the test sequence in the file 'NAME' will be executed in the automatic mode. If TEST/S 'NAME' is entered, the test sequence will be executed in the semi-automatic mode. Where 'TEST' is not followed by 'NAME', the system will be in the manual mode and will respond to and execute specific interpreter commands on the keyboard terminal.

Structure

Figure 1-9 shows the basic structure of the system control elements of the system software. The key elements are as follows:

- Input

    - via keyboard (manual mode)

    - existing test program (auto and semi-auto modes)

- Interpreter

    - interprets input command

    - checks for required data

    - calls appropriate software module

- Error Message Module

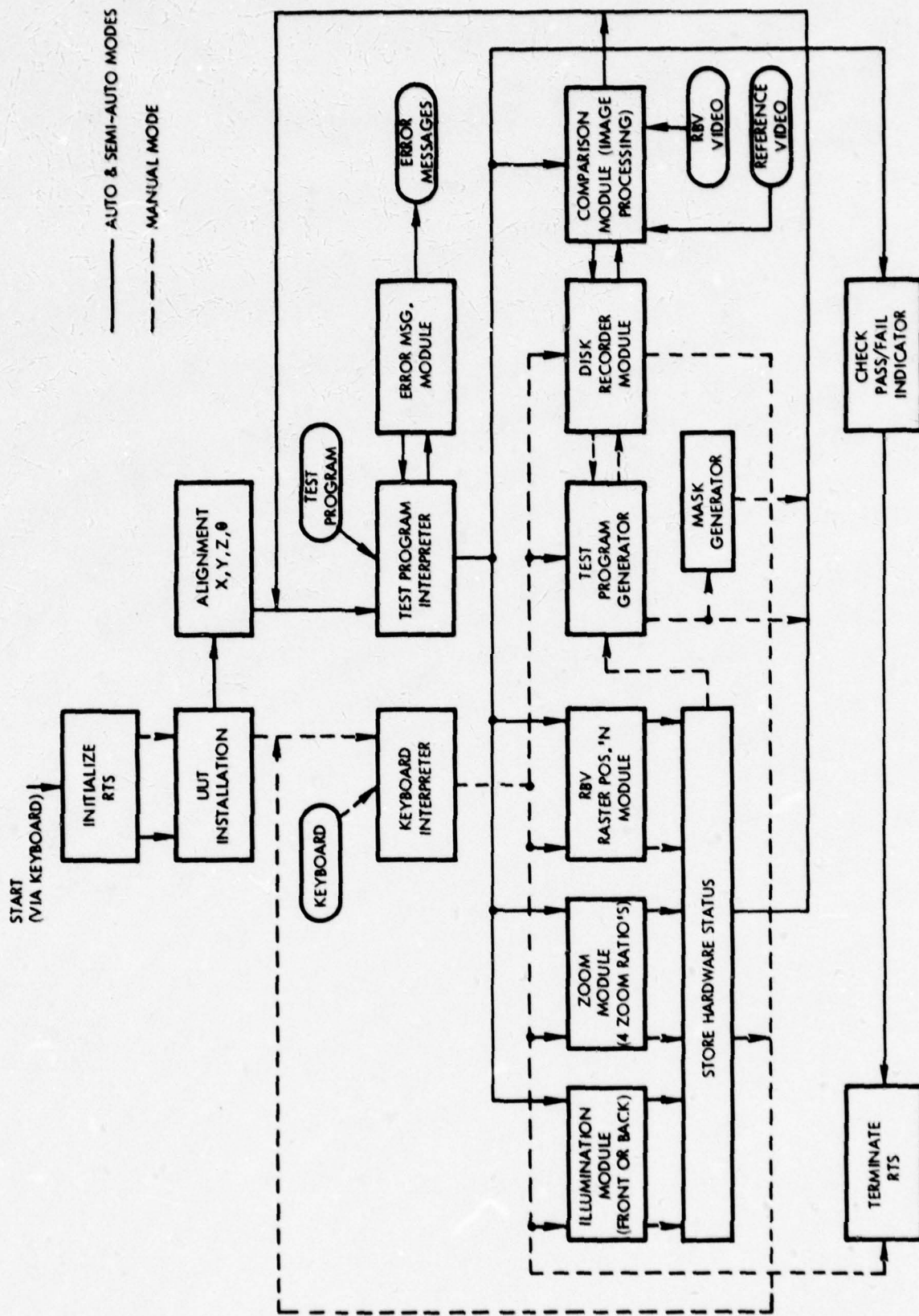    - displays error message for improper command or data

Figure 1-9. AIME Software Block Diagram

- Software Modules

  - one module for each major function

    - DISPLAY
    - RTS INITIALIZER
    - RTS TERMINATOR
    - XY POSITION
    - UUT ALIGNMENT
    - ILLUMINATION
    - ZOOM CONTROL
    - VIDEO RECORDER CONTROL
    - HARDWARE REGISTER CONTROL
    - IMAGE PROCESSING
    - PASS/FAIL DETERMINATION
    - TEST PROGRAM GENERATION
    - MASK GENERATION

  - returns to interpreter upon completion

- Common Data Storage

  - one 'external' module

  - accessible by all modules

  - stores current status of system hardware

- Keyboard Task

  - distinguishes between control keys and other inputs

  - allows direct control of hardware via keyboard

  - activates test program generation module with a 'TESTGEN' key
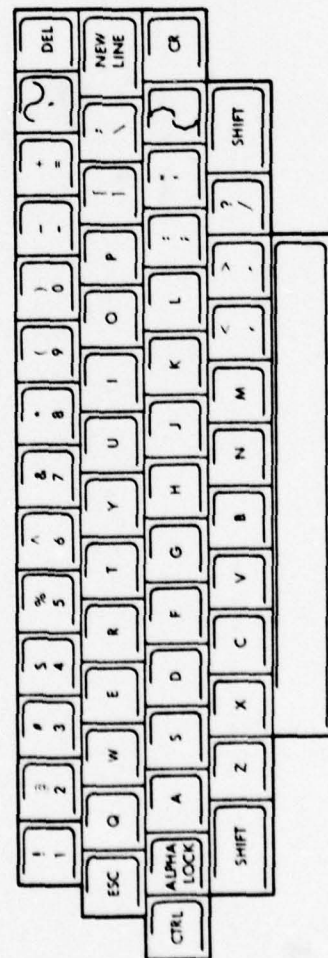
## Test Program Generation

The test program generator will be used to create automatic and semi-automatic test programs for substrates and pre-cap hybrids respectively. To create a test program, the operator enters the command TEST. This will activate the system and enable the user to manipulate the system from the keyboard. Sectors have been designated for the user in positioning the image or the monitor. The higher the zoom ratio, the greater the number of sectors. Sectors are square in shape and are numbered from left to right and from the top down. When a suitable image is seen on the monitor the operator pushes the 'TESTGEN' keyboard button which results in the following system actions:

(1) Interrogation of all system status registers and storage of the current setup data for the image.

(2) The generation of a set of commands and related setup data, which when executed at a later date will result in the exact same setup conditions.

(3) Indexing and storage of the image on the video disc-recorder.

(4) The generation of a MASK for the current image for the automatic test program.

## The Operator Keyboard

Figure 1-10 shows the configuration of the keys in the keyboard on the display terminal. The keys pertinent to the AIME system are summarized below:

- HALT          to terminate testing.

- PAUSE         to temporarily postpone execution of a program.

- PROCEED       when an operator action is required, this key is used to resume testing.

1-34

Figure 1-10 Operator Keyboard

- YES/PASS    These dual purpose keys are used when responding to
  NO/FAIL    a YES/NO or PASS/FAIL decision.

- CMD    The 11 keys below the CMD buttom are recognized as test

  control commands only when the command is preceeded by

  the depression of the CMD key.


The 11 lower keys are primarily used while operating in the manual mode.

- ZM 1    to select one of four zoom ratios for the RBV.
  ZM 1.67
  ZM 3.6
  ZM 10

- FR    to select either front or back illumination for
  BK    the UUT.

- RECALL    to recall a video image off the disc recorder for display-

  ing purposes on the color monitor. The track is selected

  by the operator.

- REC'D    to record a video image onto the disc recorder, the

  track being selected by the operator.

- DIFF    to display the difference video on the color monitor.

- TESTGEN    to automatically generate a test program using the

  current setup conditions.

- COMM    this key is used in the semi-automatic mode as a means

  for the operator to store any applicable comments he may

  make.

1-36

The remaining keys are located on the middle keypad (Figure 1-8) and are used for image positioning:

- SECT           When a specific sector wants to be seen, depressing this key will ask the operator to input any sector number.

- HOME       This will position the RBV to sector 1.

- ↑, ↓, →, ←   These 4 keys will position the RBV to the appropriate adjacent sector.

Depending on whether the generated test program is to run in the automatic or semi-automatic mode, the proper command for computer image processing/computer decision or operator inspection/operator decision will be added. The user will then proceed by using the various commands to set up further images and repeating the process above, until a suitable number of reference images have been obtained. The test program generation process will then be ended when the HALT button is pressed. This will add a pass/fail decision command to the end of the test program. The resultant test program can be printed out at any time for reference or permanent record.

## Mask Generation

The mask generator (software module MASKGEN) will be used to generate a mask for each reference image operating in the automatic mode. Where an etch boundary exists, the mask will consist of a block of '∅'s with '1's elsewhere. The width of the block of '∅'s will be sufficient magnitude to maks out offset and registration errors. The resultant mask will then be stored as a disc file. During an automatic mode run, the appropriate mask will be read into the computer memory and "AND ed" with the difference video data. The resultant data is then ready for the image processing.

## 1.2 PHYSICAL DESCRIPTION

Figure 1-11 shows the physical layout of the AIME system. There are basically two major units of the AIME demonstration system:

- Control/Display Station
- Inspection Station

Figures 1-12 and 1-14 illustrate the actual Control/Display Station and Inspection Station respectively.

### 1.2.1 Control/Display Station

The Control/Display Station consists of two racks which contain all the control and processing electronics in addition to the video monitor unit, a separate table for the display/keyboard unit, and a stand alone character printer.

Both racks are 78" high, 30" deep, and accommodate standard 19" wide panels. The right hand unit has a pull-out writing surface located just below the video monitor. Also, in this rack are the power supply units for the RBV electronics and illuminators. The AIME power distribution and RBV electronics chassis complete the right rack assembly.

The left rack consists of the computer and disc, video recorder, sync generator, and timebase corrector, as well as the I/O Processor chassis. Both racks contain their own blower assemblies for cooling. The racks will be connected together to form a single unit. There will not be a center panel separating the two racks. Elimination of this panel will allow easier inter-rack wiring.

Table 1-2 contains the major physical characteristics of the elements contained in the Control/Display Station.

TABLE 1-2  Control/Display Station Elements
Physical Characteristics

| DEVICE | WEIGHT (lbs.) | DIMENSIONS H x W x D), inches |
|---|---|---|
| Computer | 130 | 10.5 x 19 x 21 |
| Disc Subsystem | 157 | 10.5 x 19 x 30 |
| Display/Keyboard | 52 | 15 x 22 x 21 |
| Printer | 60 | 33.5 x 27.5 x 21 |
| Video Disc Recorder | 38 | 6.5 x 16.24 x 17.5 |
| Time-Base Corrector | 60 | 8.75 x 17 x 20.5 |
| Color Video Monitor | 98 | 18.5 x 17 x 22 |
| Illumination Power Supply (3 total) | 100 | 11 x 11 x 6 |
| Sync Generator | 21.5 | 19.2 x 19 x 3.5 |
| I/O Processor Chassis | 61 | 16 x 17 x 19 |
| RBV Electronics Chassis | 25 | 11 x 17 x 19 |
| RBV Power Supply Chassis | 47 | 5 x 17 x 19 |
| Power Distribution Chassis | 25 | 7 x 17 x 19 |
| Blowers (2 total) | 25 | 7 x 17 x 19 |

## 1.2.2  Inspection Station

The Inspection Station diagrammed in Figure 1-13 contains the vertically mounted RBV, three illuminators, and hybrid holding fixture.  Because of the rigidity required, the
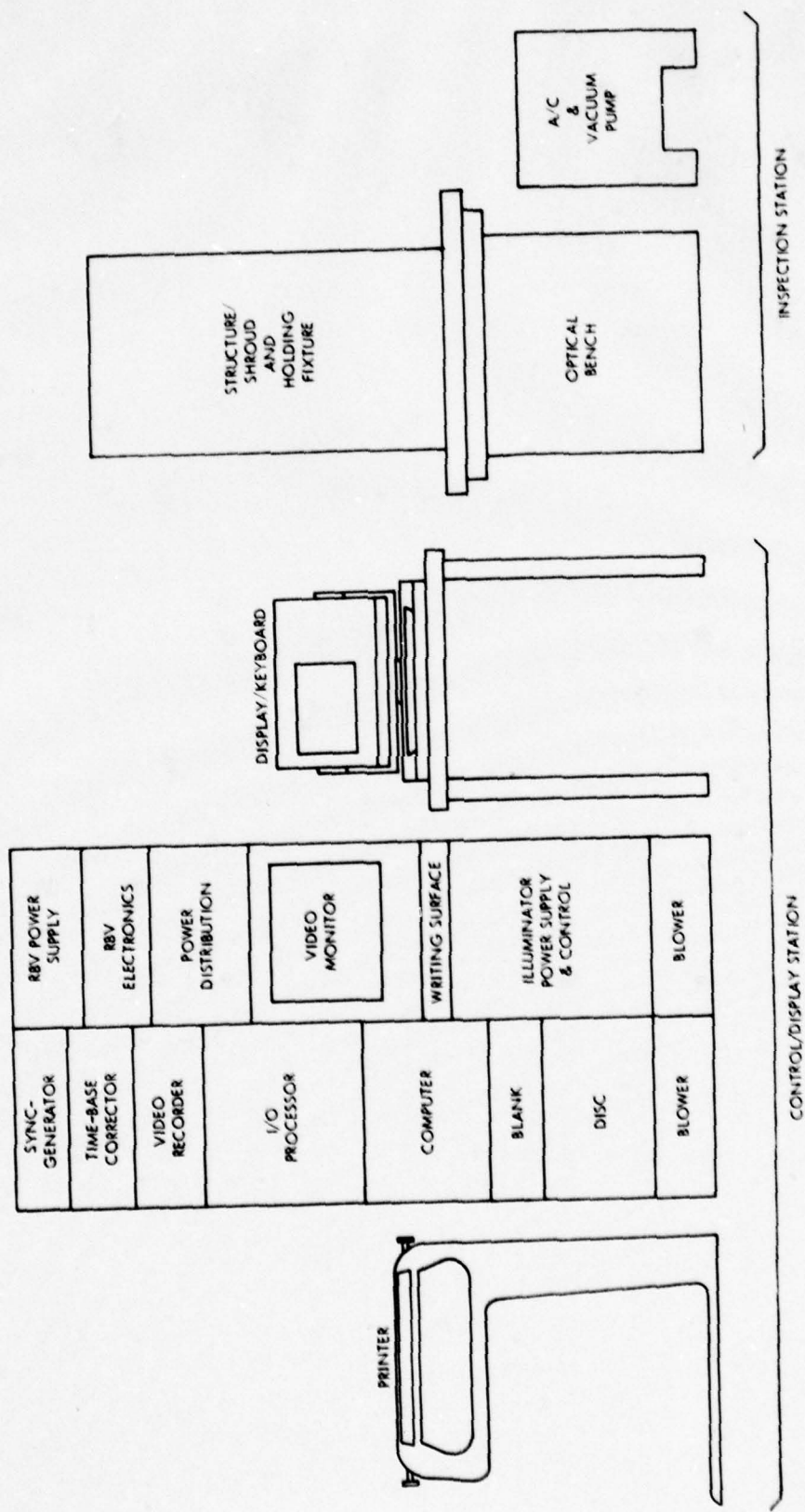
Figure 1-11 AIME Demonstration Configuration

Inspection Station structure is fabricated from extruded aluminum sections and covered with sheet metal. A 3' x 4' honeycomb optical table is used as the working surface or base for the RBV and shroud.

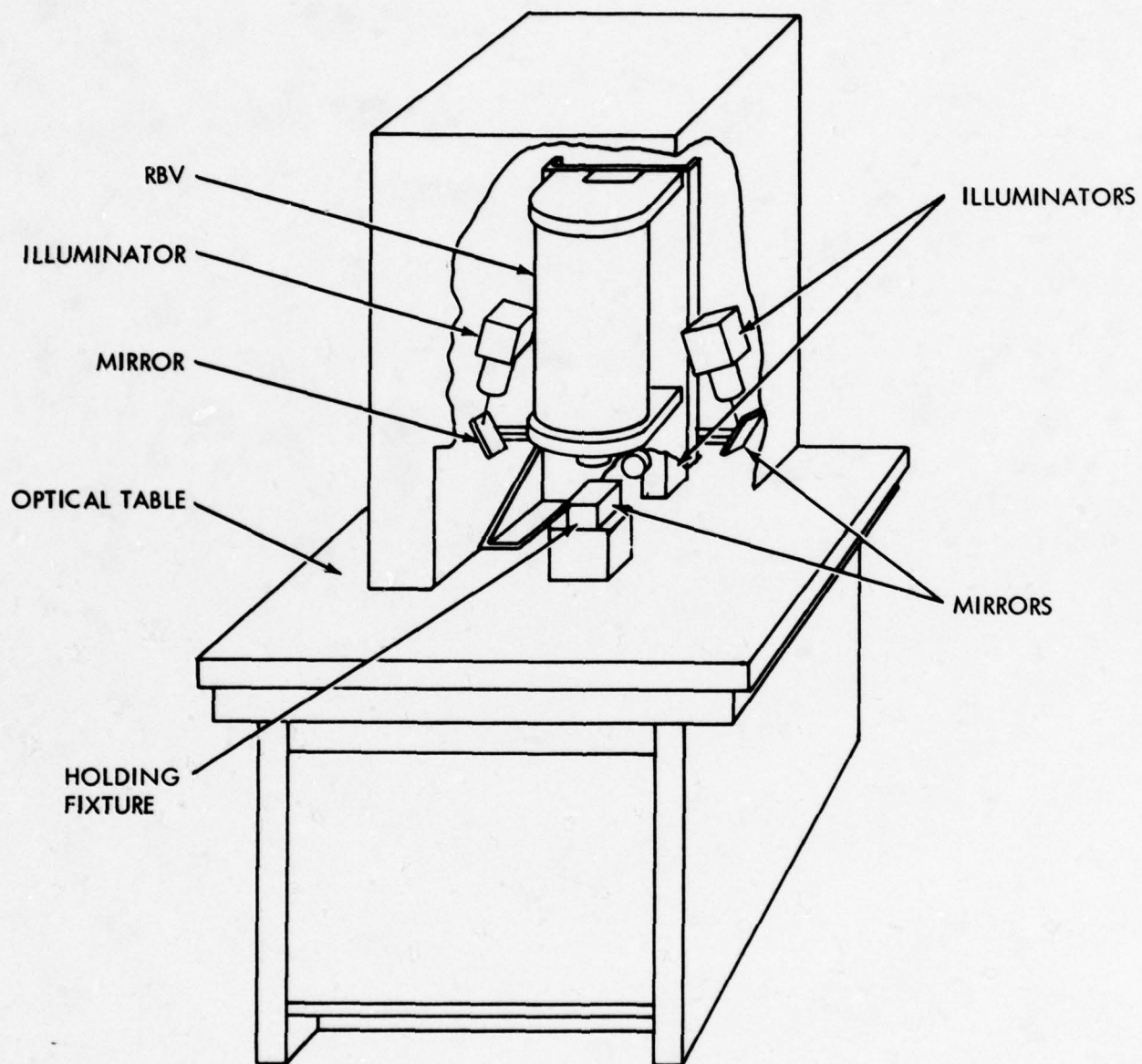Figure 1-12.   Control/Display Station

Figure 1-13. Inspection Station

Figure 1-14. Inspection Station

Cooling air for the RBV and illuminators is provided by the air conditioner unit which consists of a standard 5000 BTU window type air conditioner; a 300 CFM centrifugal fan; air collection plenum; dual outlet tubes with dampers; connecting hoses. To reduce vibrations, the air conditioning unit is located remote from the inspection station and its output is ducted through flexible hoses. The small vacuum pump is mounted on top of the air conditioning unit and provides a 25 liter per minute vacuum for the holding fixture.

The holding fixture provides four degrees of freedom, a vacuum holding capability, and precise three point locating pins as shown in Figure 1-15. Three translation stages are used to produce x, y, and z positioning. Angular positioning is obtained by fastening the orthogonally mounted translation stages on a plate, which is attached to the angular, θ, adjustment stage. A thumb screw is provided to secure this adjustment. Three guide pins provide a repeatable reference on the stainless steel reference plate. The reference plate is located on the mirror holder assembly. This assembly houses the mirror which is used for back-illumination. There is also a cut-out section in the reference plate. This cut-out is large enough to implement the back-illumination as well as accepting a special holding unit for smaller than 2" x 2" hybrid or substrate assemblies.

The optical table is fabricated from a very strong, light weight, all metal honeycomb structure with a precision ground stainless steel top surface. An array of 1/4-20 tapped holes on two inch centers allows the stable mounting of bolted accessories.

Three illuminators are mounted inside the shroud and on the structure. Two of the illuminators are mounted to the left and right of the RBV assembly. The third illuminator is mounted behind the RBV.

The light from the illuminators will be projected on the UUT via three mirrors. By this method, there will be two illuminators for illuminating the top of the UUT and the remaining illuminator will be used for back-illumination.
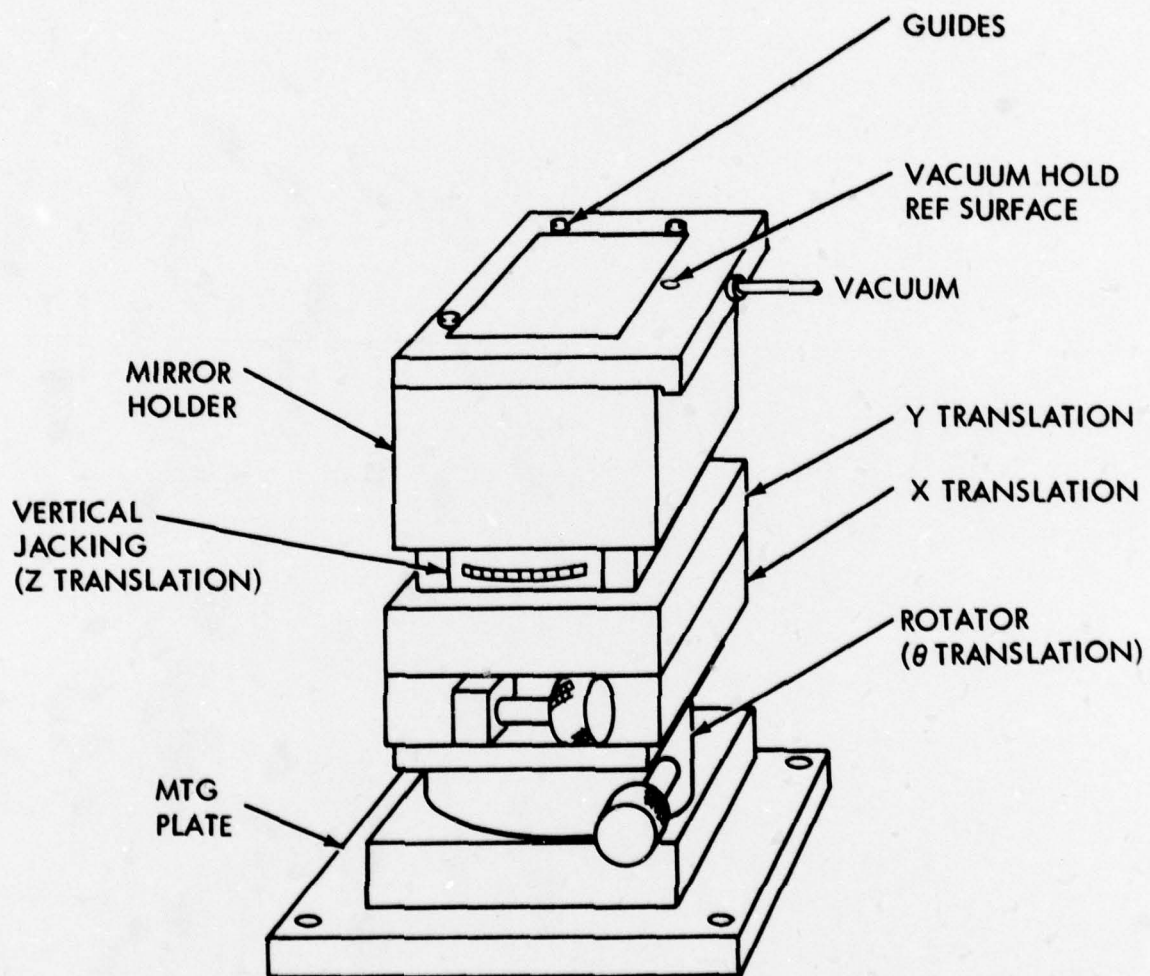
1-45

GUIDES

VACUUM HOLD
REF SURFACE

VACUUM

MIRROR
HOLDER

Y TRANSLATION

X TRANSLATION

VERTICAL
JACKING
(Z TRANSLATION)

ROTATOR
(θ TRANSLATION)

MTG
PLATE

Figure 1-15. Holding Fixture

## SECTION 2

## CONCLUSIONS

## 2.1 PROGRAM PROGRESS

### 2.1.1 Hardware Status

During the third quarter, fabrication, assembly, and test of the AIME Control/Display and Inspection Stations was completed. Among the tasks completed on the Control/Display Station are the fabrication (and/or modification) assembly of:

- Power control panel.

- IO processor chassis.

- The RBV electronics chassis.

- The 4040 board, a general purpose interface resident in the computer.

- The Processor analog circuits.

- RBV camera.

The time-base corrector was modified to bring out a 14.3 MHz clock signal. The video disc recorder was also modified to permit selection of the sync source.

Cables were also fabricated to connect the various AIME system elements. These cables included some taken from the AIDE system, a large number of 75$\Omega$ coax cables used to route the video signals, and multiconductor data-bus cables.

The Control/Display Station racks were also wired to provide AC power to the AIME system elements. Finally, the control station elements were installed in the rack and their interconnections completed.

Integration of the AIME system was started in mid-April and concluded on 26 June with the completion of SLIN 0001AA and SLIN 0001AB. Integration of the AIME system included:

- The sync generator with the RBV Electronics chassis.

- The RBV Electronics chassis with the associated camera in the local mode.

- The illuminator controller with the RBV Electronics.

- The Video-disc recorder with the TBC and the sync generator.

- The video processor analog circuits with the Video-disc recorder and RBV Electronics chassis.

- The computer interface with the IO circuits located in the IO processor chassis.

- The IO circuits with the AIME system elements.

- The power control panel with the AIME system elements.

Integration of the Video-disc recorder into the system has been greatly hampered by the poor reliability of the unit. From receipt of the unit on 25 April until the end of June [nine (9) weeks] the unit was operational only five (5) weeks. During the other four (4) weeks it was either at the vendors for repairs or in transit between RCA and the vendor.

The fabrication of the Inspection Station was completed at the end of May. The RBV camera and substrate holding fixture were installed and aligned. The wiring harness from the AIDE Inspection Station was removed, modified and installed into the AIME Inspection Station. Finally, the illuminator housings were mounted; two on the RBV camera mount and one behind the substrate holding fixture on the inspection station surface.

### 2.1.2 Software Status

The AIME system control software was started during April. At that time validation of this software did not include the IO circuits in the IO processor chassis. Validation of the control software with the IO circuits began in May and ended by the middle of June at which time validation was complete.

The design and coding of the image evaluation software was accomplished during April and May. A mask generation software module creates a digital mask from the reference image which has been thresholded digitized and stored on the disc bulk storage unit. The mask is logically AND'ed with the video difference data. After this logic operation is completed, the remaining data is evaluated for printing faults on the substrate under test.

### 2.1.3 Hybrid Status

The design and layout of the sample substrates was completed during the third quarter. The artwork was ordered and the printing screens procured. Delivery is expected at the beginning of July.

# SECTION 3

## PROGRAM FOR THE NEXT INTERVAL

### 3.1    HARDWARE

All hardware tasks are complete.  Modifications to the existing circuits will be made as required during validation of the image program.

### 3.2    HYBRID SAMPLES

The hybrid samples will be delivered during July.

### 3.3    SOFTWARE

Validation of the image program will take place during the next quarter.  Further, the UUT program will be coded and validated.

### 3.4    OTHER

Acceptance tests will be conducted during the last week of August.  Demonstrations of the AIME system will take place during September.

Evaluate AIME hardware/software system using test sample substrates and hybrid pre-cap samples to determine system capabilities.

Use results of evaluation data to prepare specifications for future procurement of reproducible AIME systems.

Prepare and deliver remaining Data Items.

# SECTION 4

## PUBLICATION AND REPORTS

### 4.1  <u>PUBLICATIONS</u>

Five (5) reports were prepared and submitted during this period.

| <u>Report</u> | <u>Contract Reference</u> | <u>Date</u> | <u>Author</u> |
|---|---|---|---|
| Monthly Status Report No. 6 | CLIN 0004/C001 | 10 April 1978 | J. M. Laskey |
| Monthly Status Report No. 7 | CLIN 0004/C001 | 10 May 1978 | J. M. Laskey |
| Draft Second Quarterly Report | CLIN 0004/C002 | 18 May 1978 | R. J. Wildenberger |
| Monthly Status Report No. 8 | CLIN 0004/C001 | 12 June 1978 | J. M. Laskey |
| Final Second Quarterly Report | CLIN 0004/C002 | 30 June 1978 | R. J. Wildenberger |

### 4.2  <u>CONFERENCES</u>

A meeting was held on 13 June 1978 at Fort Monmouth, New Jersey, with Mr. J. F. Kelly and Mr. I. H. Pratt.  The purpose of the meeting was to coordinate the changes necessary due to Mr. Pratt's assuming the Technical Monitor responsibility in place of Mr. Kelly, who has been reassigned.  Program schedule, financial, and integration status was reviewed.  A general discussion was held concerning the theory and operation of the system and other potential applications of the AIME system.

On 22 June, Mr. I. H. Pratt visited RCA, Burlington, to review the status of the AIME test and integration effort and discussions of the procedures to be followed for test and demonstration of the completion of SLIN 000AA and SLIN 0001AB schedule for 26 June.

## SECTION 5

## KEY PERSONNEL

### 5.1    ASSIGNMENT

Key personnel from management, engineering and manufacturing, who contributed to the AIME program during this period are listed in Table 5-1.  Each individual was selected because of the proven skills and background he brings to this program.  Biographical information on each assigned individual is included in prior Quarterly Reports.

Table 5-1.  Key Management, Engineering and Manufacturing Personnel

| Name | Title | AIME Program Primary Function | AIME Man–Hours During Period |
|---|---|---|---|
| J. M. Laskey | Manager, Project Management | AIME Program Manager | 121 |
| R. J. Wildenberger | Manager, AT&MS Engineering | AIME Program Design Manager | 43 |
| L. Arlan | Manager, Engineering Design | TV System Design | 69 |
| J. J. Klein | Manager, Engineering Design | TV System Design | - |
| K. E. Ghostlaw | Manager, Project Design | Mechanical Design | 24 |
| R. B. Mark | Senior Engineering Scientist | Optical/Mechanical System Design | 374 |
| M. J. Cantella | Senior Engineering Scientist | Electro/Optical System Design | 125 |
| P. F. Minghella | Senior Project Member | Mechanical Design | 464 |
| M. W. Stewich | Senior Project Member | RBV System Design | 338 |
| B. T. Joyce | Senior Engineering Scientist | Manufacturing Hybrid Design and Fabrication | 63 |
| T. J. Dudziak | Member | Electrical Design | 485 |
| E. W. Ketler | Senior Project Member | Electrical Design | 3 |
| M. F. Krayewsky | Member | Software Des | 443 |
| E. C. Lea | Senior Member | Electro/Optical System Design | 389 |

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General Instrument Corp.                    1       Arthur D. Little                           1
Semiconductor Products Group                        Acorn Park
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Hicksville, Long Island, NY   11802                 Cambridge, MA   02140

Hughes Aircraft Corporation                 1       Motorola, Inc.                            1
Attn: Dr. Bruce Crammer                             Attn: Mr. J. LaRue
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Los Angeles, CA   90009                             Cambridge, MA   02139

Hughes Aircraft Company                     1       Microwave Associates                      1
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